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COAL-MINE EXPLOSIONS AND COAL- AND METAL-MINE FIRES IN THE UNITED STATES DURING THE FISCAL YEAR ENDED JUNE 30, 1938

BY

D. HARRINGTON AND W. J. FENE

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COAL-MINE EXPLOSIONS AND COAL- AND METAL-MINE FIRES IN THE UNITED STATES DURING THE FISCAL YEAR ENDED JUNE 30, 1938 [1]

By D. Harrington [2] and W. J. Fene [3]

INTRODUCTION

The record of fatalities from mine explosions in the United States during the fiscal years 1934 to 1937 was the best in the history of the mining industry; that for the fiscal year 1938, however, is not so favorable, since nearly as many men (170) were killed by explosions in 1938 as were killed during all of the previous 4 years (182). In spite of the large increase in fatalities from explosions during 1938, the average for the past 5-year period (70.4) is less than one-half the average (153) of the preceding 5-year period.

The reasons for the large increase in the number of explosion fatalities during the past year as compared with the previous 4 years are not entirely clear; it is evident, however, that in some instances there has been laxity in the enforcement of State mining laws, and also that some of our coal-mining people, including workers and operating officials, have failed to carry out the known precautionary measures to prevent explosions.

A study of contributory causes of a great number of explosions has shown that the factor responsible for most explosions is inadequate or interrupted ventilation; it is obvious that if adequate ventilation is maintained, explosions will be largely eliminated, though ventilation is no cure-all, as very serious disasters can and do occur in well-ventilated mines or parts of mines.

SUMMARY OF MINE EXPLOSIONS BY STATES AND CAUSES

Table 1 summarizes essential data on 29 explosions that occurred in 11 States and Alaska and resulted in 170 deaths during the fiscal year ended June 30, 1938. This table includes information on all explosions in coal mines in the United States that were brought to the attention of the Safety Division of the Bureau of Mines during the fiscal year, and it is believed to include information on every explosion in which life was lost or considerable damage resulted. The 29 explosions that occurred during the year constituted 9 more than during the previous year, and the number of deaths (170) was 108 more than in the previous year, when only 62 fatalities were chargeable to coal-mine explosions.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7048."

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The States with the greatest number of deaths from explosions during the fiscal year were Virginia, 46; Alabama, 37; Pennsylvania, 30; Indiana, 22; Alaska, 14; Illinois, West Virginia, and Wyoming, 5 each; Arkansas, 4; and Ohio, 2. Pennsylvania had the greatest number of explosions, 7 (4 in anthracite mines); Arkansas had 4 explosions; Virginia and West Virginia, 3 each; Alabama, Illinois, Indiana, and Kentucky, 2 each; and Alaska, Ohio, Washington, and Wyoming, 1 each.

Eight major explosions, resulting in 146 deaths, occurred during the fiscal year. (A major explosion is one in which 5 or more persons are killed.) During 1936 there were 2 major explosions with 17 deaths, and during 1937 there were 5 major explosions with 47 deaths. Ten of the explosions that occurred during the year did not result in fatalities.

TABLE 1. - Summary of explosions by States and causes, fiscal year 1938

State	Lighting used			Fatalities by ignition causes									
	Open	Closed	Unknown	Electricity		Open lights or smoking		Explosives		Miscellaneous or unknown		Total	
				Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions
Alabama	-	2	-	3	1	34	1	-	-	-	-	37	2
Alaska	-	1	-	-	-	14	1	-	-	-	-	14	1
Arkansas	2	2	-	-	-	4	3	-	1	-	-	4	4
Illinois	2	-	-	-	-	5	2	-	-	-	-	5	2
Indiana	2	-	-	2	1	20	1	-	-	-	-	22	2
Kentucky	2	-	-	-	-	-	2	-	-	-	-	-	2
Ohio	-	1	-	2	1	-	-	-	-	-	-	2	1
Pennsylvania .	-	4	3	12	4	-	-	10	1	8	2	30	7
Virginia	1	2	-	-	-	-	1	46	2	-	-	46	3
Washington ...	-	1	-	-	-	-	-	-	1	-	-	-	1
West Virginia.	-	3	-	5	3	-	-	-	-	-	-	5	3
Wyoming	1	-	-	-	-	-	-	5	1	-	-	5	1
Total	10	16	3	24	10	77	11	61	6	8	2	170	29

Twenty-four persons were killed during the past fiscal year in explosions initiated by electricity compared with 53 deaths the previous year and an average of 30 deaths per year for the preceding 5 years. Deaths from explosions due to electricity decreased slightly during the past year over the average of the past 5 years; this is a substantial decrease when compared with the average of 131 deaths from explosions of electrical origin during the period 1929-1931, inclusive. (See table 2.) There were 10 electrical explosions during 1938 compared with 12 such explosions in the previous year and an average of 11 for the previous 9 years. The greatest number of electrical explosions (4) occurred in Pennsylvania and resulted in 12 deaths; West Virginia had 3 such explosions with 5 deaths; and Alabama, Indiana, and Ohio had one each, with a total of 7 deaths.

During the fiscal year 1938, 11 explosions were caused by open lights or smoking compared with 5 during 1937 and an average of 10.2 during the previous 9 years. Deaths due to explosions caused by open lights or smoking last year numbered 77 compared with 3 deaths from this cause during 1937 and an average of 23 during the previous 9 years. Explosions caused by open lights or smoking were distributed as follows: Arkansas, 3, with 4 deaths; Illinois and Kentucky, 2 each, with a total of 5 deaths; and Alabama, Alaska, Indiana, and West Virginia, 1 each, with a total of 68 deaths. In spite of the greatly increased use of electric cap lamps in our mines, deaths from explosions caused by open lights were more numerous during 1938 than in any year during the past 10 years. One of these explosions, which resulted in 34 deaths, is suspected of having been caused by a shot firer attempting to relight his nonpermissible flame safety lamp with a match; another explosion due to the same practice resulted in the injury of 6 men. Smoking was responsible for 2 of these explosions, which resulted in 14 deaths and 7 injuries.

Explosives were responsible for 6 explosions and 61 deaths during the past fiscal year compared with 1 explosion and no deaths the previous year and an average of 4 explosions and 17.2 deaths per year from this cause during the previous 9 years. Four of these explosions were due to blown-out shots of black powder which killed 5 and injured 6 men; 1 was due to an overcharged shot of pellet black powder, which resulted in 10 deaths and 6 injuries; and one was due to an "adobe" or "bulldozing" shot using permissible explosives in a strictly nonpermissible manner, which resulted in 45 deaths and 2 injuries. During the previous 4 years only 9 deaths resulted from explosions caused by explosives.

Two explosions from miscellaneous or unknown causes resulted in 8 deaths and 12 injuries. One of these explosions was probably caused when gas was ignited by an old mine fire; in the other the source of ignition could not be determined but it is likely to have resulted from open lights or smoking, though electricity may have been responsible.

TABLE 2. - Summary of explosions by causes, fiscal years 1929-38

	Lighting used			Fatalities by ignition causes									
	Open	Closed	Unknown	Electricity		Open lights or smoking		Explosives		Miscellaneous or unknown		Total	
				Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions
1929	18	19	1	93	18	14	11	26	8	6	1	139	38
1930	8	25	1	154	18	21	8	24	6	-	2	199	34
1931	12	14	-	143	9	56	11	18	6	-	-	217	26
1932	15	14	4	11	10	33	15	42	5	1	3	87	33
1933	7	14	1	25	8	63	8	29	4	5	2	122	22
1934	9	14	3	21	10	2	9	2	3	3	4	28	26
1935	6	17	-	29	10	6	9	3	2	16	2	54	23
1936	15	9	1	20	5	10	17	4	1	4	2	38	25
1937	4	12	4	53	12	3	5	0	1	6	2	62	20
1938	10	16	3	24	10	77	11	61	6	8	2	170	29
Total, 10 years.	104	154	18	573	110	285	104	209	42	49	20	1,115	276

RECORD OF MINE EXPLOSIONS BY STATES

Table 3 shows the record of explosions, by States, during the past 10 fiscal years. During this 10-year period, 276 explosions caused 1,116 deaths, an average of 27.6 explosions and 111.6 deaths per year; hence, the number of explosions (29) and deaths (170) during the past year was greater than the average for the 10 years, this being especially true of the deaths. For this 10-year period, Pennsylvania leads in total number of known explosions (88) and the largest number of deaths (217); West Virginia is next, with 50 explosions and 147 deaths; and Oklahoma, with only 12 explosions, had the next largest number of deaths (126) and had no known explosions during 4 years of this period. It is of interest to note that during the 10-year period Kansas and Maryland had 1 explosion each, with a total of 3 deaths; Tennessee had 4 explosions without a fatality in 10 years; Alaska experienced its first explosion during the past year; Kansas has not had an explosion during the past 9 years; and Utah has had none for the past 8 years.

The average number of deaths per explosion during the past 10 years is 4.04, with a range for the various States from none to 14 deaths per explosion. States with the most deaths per explosion during the past 10 years are Alaska (14), there being only one explosion involved, Oklahoma (10.5), Ohio (9.8), and Virginia (9.54); it is noteworthy that in these States relatively little attention has been given to rock-dusting or to the use of closed lights and to precautions with electrical equipment. The following coal-producing States are not listed in table 3, as they are not known to have had an explosion during the past 10 years - Iowa, Michigan, Missouri, Montana, North Dakota, and Texas.

TABLE 3. - Record of explosions by States during last 10 fiscal years

State	1929		1930		1931		1932		1933		1934		1935		1936		1937		1938		Total 10 yrs.		Average per year		
	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Average deaths per ig-nition
Alabama ..	13	7	8	4	-	2	4	5	-	-	2	2	-	1	-	1	-	-	37	2	64	24	6.4	2.4	2.66
Alaska ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	1	14	1	1.4	.1	14.00
Arkansas .	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1	4	4	9	5	.9	.5	1.80
California	-	1	7	2	12	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	19	6	1.9	.6	3.17
Colorado .	-	-	-	1	-	-	4	3	1	1	-	-	-	-	12	2	1	1	-	-	18	8	1.8	.8	2.25
Illinois .	-	3	10	2	2	1	3	3	54	1	-	-	-	-	-	-	-	-	5	2	74	12	7.4	1.2	6.19
Indiana ..	-	-	-	-	28	1	-	-	4	2	-	-	-	-	2	3	-	-	22	2	56	8	5.6	.8	7.00
Kansas ...	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	.2	.1	2.00
Kentucky .	11	3	16	1	-	-	3	1	26	2	-	1	1	1	9	1	0	-	-	2	66	12	6.6	1.2	5.50
Maryland	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	.1	.1	1.00
New Mexico	-	-	-	-	8	3	-	-	14	1	-	-	-	-	-	-	-	-	-	-	22	4	2.2	.4	5.50
Ohio......	3	3	1	2	88	3	-	-	-	-	-	-	-	-	4	1	-	-	2	1	98	10	9.8	1.0	9.80
Oklahoma..	1	1	71	4	45	2	-	-	3	2	-	-	3	2	-	-	3	1	-	-	126	12	12.6	1.2	10.50
Pennsylvania	70	9	16	8	23	7	7	6	9	6	16	14	24	11	8	10	14	5	30	7	217	88	21.7	8.8	2.46
Tennessee.	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	1	0	-	-	4	-	.4	-
Utah	1	2	30	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31	5	3.1	.5	6.00
Virginia	2	1	-	-	-	-	54	3	-	-	2	3	18	2	-	-	2	1	46	3	124	13	12.4	1.3	9.54
Washington	-	-	17	2	-	2	-	-	2	1	-	2	-	-	-	4	1	2	-	1	20	14	2.0	1.4	1.43
W.Virginia	36	7	23	5	11	4	11	7	9	5	8	4	5	4	3	3	36	8	5	3	147	50	14.7	5.0	2.94
Wyoming ..	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-	5	1	8	2	.8	.2	4.00
Total ...	139	38	199	34	217	26	87	33	122	22	28	26	54	22	38	25	62	20	170	29	1,116	276	111.6	27.6	4.04

CAUSES OF EXPLOSIONS

Table 4 gives data on causes of explosions in the United States during the past 10 years, as reported to the Safety Division of the Bureau of Mines by its field investigators. In all, 276 explosions have been studied during the 10-year period, an average of 27.6 explosions per year. There were 29 explosions during the past fiscal year, which is 9 more than during the previous year and 1.4 more than the average for the past 10 years.

Table 4 shows that electricity was responsible for 110 (39.9 percent) and open lights and smoking for 104 (37.7 percent); hence, 77.6 percent of all explosions during this 10-year period were started by ignitions due to electricity, open lights, and smoking.

The number of explosions of electrical origin during the past year (10) is slightly less than the average of the preceding 9 years (11), while the number caused by open lights or smoking (11) is slightly more than the average from those causes during the previous 9 years. During 1937 there was a substantial decrease in the number of explosions caused by open lights or smoking, and it was thought that the rapid introduction of the use of up-to-date electric cap lamps was largely responsible for this decrease; however, the record of 1938 does not bear out this conjecture, as there are fewer open lights in our mines today than there were 10 years ago, but explosions due to open lights or smoking have increased rather than decreased during that time. Undoubtedly much of the trouble is due to lack of discipline in "winking" at smoking and also to the utterly reprehensible practice of using open lights in mines classed as nongassy yet known to give off explosive gas in some degree or under some circumstances.

Table 4 shows that there was a marked increase in the number of explosions (6) caused by explosives compared with the previous year (1); however, explosions from this cause decreased from 8 in 1929 to 1 in 1936 and 1937, and 6 last year. This favorable reduction in explosions caused by explosives during the past 10 years, excluding 1938, may be attributed chiefly to the increased use of permissible explosives, to increase in safe practices in the handling of explosives, to improved ventilation, and to more intensive supervision. In five of the six explosions caused by explosives during the past year, black blasting powder was responsible, and the other one was due to a "bulldozing" shot of permissible explosives fired from a trolley wire, a decidedly dangerous practice and a definite misuse of permissible explosive. In all of these cases lack of proper supervision and of safe and sane mining practice is indicated. Black powder in either granular or pellet form creates an unnecessary hazard in and around mines, and it should not be used in mining work, permissible explosives of essentially any desired type can be obtained and if used with judgment are not only relatively safe but also can be efficient from an economic point of view.

Of the two explosions listed under unknown or miscellaneous causes, one is reported to have been caused by an old mine fire igniting gas; the cause of the other explosion under this classification was unknown, but the ignition source could have been open lights, smoking, or electricity.

TABLE 4. - Comparison of explosions by ignition causes, fiscal years 1929-38, inclusive

Year	Ignition by electricity		Ignition by open lights or smoking		Ignition by explosives		Ignition due to unknown or miscellaneous causes		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1929...........	18	47.4	11	29.0	8	21.0	1	2.6	38	100
1930...........	18	52.9	8	23.5	6	17.6	2	6.0	34	100
1931...........	9	34.6	11	42.3	6	23.1	-	-	26	100
1932...........	10	30.3	15	45.5	5	15.1	3	9.1	33	100
1933...........	8	36.4	8	36.4	4	18.1	2	9.1	22	100
1934...........	10	38.5	9	34.6	3	11.5	4	15.4	26	100
1935...........	10	43.5	9	39.1	2	8.7	2	8.7	23	100
1936...........	5	20.0	17	68.0	1	4.0	2	8.0	25	100
1937...........	12	60.0	5	25.0	1	5.0	2	10.0	20	100
1938...........	10	34.5	11	37.9	6	20.7	2	6.9	29	100
Total, 10 yrs.	110	39.9	104	37.7	42	15.2	20	7.2	276	100
Average per yr.	11	39.9	10.4	37.7	4.2	15.2	2	7.2	27.6	100

EXPLOSION FATALITIES BY CAUSES

Table 5 compares explosion fatalities by causes and shows that during the past 10 years, 1,116 fatalities resulted from explosions in mines in the United States, an average of 111.6 per year. The safety performance of the 4 years previous to 1938, an average of 45.5 deaths from mine explosions per year, is by far the best since records have been available; however, the past year's record is anything but favorable, and the number of deaths from mine explosions in the United States has been exceeded in only 2 years of the past 10.

Explosions of electrical origin were responsible for 24, or 14.1 percent, of the deaths from explosions during the past year; this is a marked decrease in fatalities from this type of explosion when compared with the average of 56.7 percent for the preceding 9 years. In view of the rapid increase in use of underground electrical equipment during the past several years, the record for 1938 was favorable; however, all of the explosions of electrical origin that occurred during the year and all of the fatalities from them probably could have been avoided if permissible equipment had been used.

Open lights and smoking caused explosions that resulted in 77 deaths, or 45.3 percent of all fatalities due to explosions during the past fiscal year; this is a substantial increase compared to the average of 20.6 percent per year during the previous 9 years. Deaths due to explosions caused by open lights and smoking had gradually decreased during the period 1929 to 1937; however, the past year's record was most unfavorable. Four of the 11 explosions caused by open lights during the past year resulted in no deaths. Two of these explosions are reported to have been caused by fire bosses attempting to relight their flame safety lamps with matches in the presence of gas. Apparently some of our fire bosses have not learned to give proper respect to the hazard of gas; however, the mine management is primarily responsible for this type of explosion for permitting the use of nonpermissible flame safety lamps and for failure to impress upon fire bosses and mine foremen the limitations of the flame safety lamp. It seems the height of inconsistency to equip a mine with closed lights and permissible electrical equipment and then to permit underground officials to carry nonpermissible flame safety lamps. Smoking is reported to have been responsible for two explosions resulting in 14 deaths and 7 injuries, both of which were in closed-light mines. This vicious practice can be stopped if proper steps are taken to educate the underground workers, including officials, and to enforce rigidly at all times and against all persons the no-smoking regulations; and it is the acme of inconsistency to allow smoking in any mine that gives off explosive gas, especially if closed lights are used. Explosions will continue to occur in so-called nongassy mines so long as State laws permit the use of open lights in coal mines; common sense demands that open lights and smoking be excluded from any mine in which explosive gas is found.

TABLE 5. - Comparison of explosion fatalities by ignition causes, fiscal years 1929-38, inclusive

Year	Electricity		Open lights or smoking		Explosives		Unknown or miscellaneous causes		Total	
	Number killed	Per-cent	Number killed	Per-cent	Number killed	Per-cent	Number killed	Per-cent	Number killed	Per-cent
1929..............	93	65.9	14	10.1	26	18.7	6	4.3	139	100
1930..............	154	77.4	21	10.5	24	12.1	-	-	199	100
1931..............	143	65.9	56	25.8	18	8.3	-	-	217	100
1932..............	11	12.7	33	37.9	42	48.3	1	1.1	87	100
1933..............	25	20.5	63	51.6	29	23.8	5	4.1	122	100
1934..............	21	75.0	2	7.1	2	7.1	3	10.8	28	100
1935..............	29	53.7	6	11.1	3	5.6	16	29.6	54	100
1936..............	30	52.6	10	26.4	4	10.55	4	10.55	38	100
1937..............	53	85.5	3	4.8	0	-	6	9.7	62	100
1938..............	24	14.1	77	45.3	61	35.9	8	4.7	170	100
Total, 10 years.	573	51.4	285	25.5	209	18.7	49	4.4	1,116	100
Average per year	57.3	51.4	28.5	25.5	2.09	18.7	4.9	4.4	111.6	100

During the past 10 years, 209 deaths (18.7 percent of all deaths due to explosions during this period) resulted from explosions caused by the misuse of explosives. The record of explosions caused by explosives during the 4 years previous to 1938 was good, as there were only 9 deaths during this period. The radical increase in deaths from explosions caused by explosives during 1938 (61) is difficult to explain. During the period 1934-37, while the record in connection with this cause of explosions was good, it was thought that the increased use of permissible explosives and safer practices in the handling of explosives, were largely responsible for this favorable record. These conditions prevailed, even on an increased scale, during 1938; but in spite of this, fatalities from explosions started by explosives increased radically. Regardless of contributory factors, the policies regarding the use of explosives are formulated chiefly by the mine operator; hence, it is largely his responsibility to prevent accidents and explosions due to explosives even though the immediate cause of some of these explosions is some act of omission or of commission by mine workers.

During the past 10 years 49 persons were killed in mines in the United States in 20 explosions due to miscellaneous or unknown causes. During the past fiscal year two explosions in anthracite mines, which caused 8 deaths, were listed under this classification. It is often difficult, if not entirely impossible, to determine definitely the cause of an explosion, because usually the persons implicated in the origin are killed, and in many instances surrounding conditions are changed to such an extent or are of such nature that available evidence is not sufficient to reveal the cause; therefore, it is remarkable that over a period of 10 years, fewer than 5 percent of the explosions or of the fatalities from them are listed as of unknown or miscellaneous cause.

ELECTRICAL CAUSES OF EXPLOSIONS

Table 6 gives data available to the Bureau of Mines relating to details of the causes of explosions of electrical origin in the United States during the past 10 years. During this period there were 110 explosions of electrical origin, 10 of which, with 24 deaths, occurred during the past fiscal year. The greatest sources of explosions attributed to electricity in coal mines are trolley or cable-reel locomotives and nonpermissible mining machines, which, jointly, were responsible for more than half of the electrical explosions during the 10-year period and for 70 percent of the electrical explosions during the past year.

In most electrical ignitions that have occurred during the past 10 years there has been much evidence of carelessness or flagrant disregard of safe ventilation practices, such as doors left open on main or important haulage entries or line brattices in poor condition or not extended close enough to the face, or several other similar manifestations of neglect. Other factors concerned in these electrical ignitions were (1) failure to test for gas before going into the working place with electrical equipment, such as a mining machine, trolley locomotive, or electric drill; (2) use of electrical equipment too soon after the mine fan had been started following a period of shutdown; (3) failure properly to examine a mine on idle days when only a skeleton crew is in the mine; and (4) use of haulageways as return airways (this practice always having been hazardous in the extreme, whether in gassy or so-called nongassy mines).

TABLE 6. - Electrical causes of explosions, fiscal years 1929-38, inclusive

Cause	Number of electrical explosions by fiscal years										Total, 10	Number killed	
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	years	1937	1938
Trolley or cable-reel locomotive.	1/ 5	5	1	1	4	5	3	1	5	4	33	25	16
Nonpermissible mining machine....	2/ 5	5	3	3	1	-	2	1	3	3	25	7	5
Nonpermissible electric motors..	4	3	-	-	-	-	2	-	-	1	10	-	2
Nonpermissible shot-firing battery or circuit............	-	3/ 2	3/ 3	1	-	1	-	-	-	-	2	-	-
Cable nips or cable blowout.....	-	2	-	-	-	1	-	-	1	-	4	18	-
Nonpermissible electric drill....	-	-	-	2	-	1	2	-	-	-	5	-	-
Nonpermissible storage battery locomotive....................	1	1	2	-	-	-	-	-	-	-	4	-	-
Nonpermissible electric hoist....	-	-	-	-	1	-	-	-	-	-	1	-	-
Faulty wiring..................	2	2	-	-	-	-	-	1	1	-	6	1	-
Trolley wire....................	1	-	2	1	-	-	-	1	-	-	5	-	-
Electric arc....................	2	-	1	2	1	2	1	4/ 1	1	2	13	2	1
Signal wire.....................	-	-	-	-	1	1	-	-	1	-	2	-	-
Total........................	18	18	9	10	8	11	10	5	12	10	110	53	24

1/ One not included in total; may have been from open light.
2/ One not included in total; may have been from smoking.
3/ Not included in total; may have been from overcharged shot.
4/ Included, but may have been from smoking.

COMPARISON OF LIGHTING IN MINES WHERE EXPLOSIONS OCCURRED

Table 7 shows data as to methods of lighting in mines where explosions have occurred during the past 10 fiscal years. It is observed that of the 276 explosions that occurred during this period, 104, or 37.7 percent, were in open-light mines; 154, or 55.8 percent, were in closed-light mines; and 18, or 6.5 percent, were in mines in which the lighting practice was unknown. During the past fiscal year, 10, or 34.5 percent, of the explosions occurred in open-light mines, as compared to an average of 10.5 explosions in open-light mines during the preceding 9 years. The fact that during the past fiscal year 55.2 percent of the explosions occurred in closed-light mines and that during the past 10 years 55.8 percent of all explosions occurred in mines using closed lights may be interpreted in several ways, and probably the most nearly correct explanation is that in most States gassy mines are required to use closed lights. No explosion has ever started by an electric cap lamp; this indicates carelessness in connection with other explosion-prevention methods and practices in at least some closed-light mines. There is good reason to believe that in many mines in which closed lights are adopted undue dependence is thereafter placed on the lamps, with more or less flagrant neglect of ventilation and other precautionary measures.

EXPLOSIONS IN BITUMINOUS COAL MINES

The graph shows the fatalities resulting from gas and dust explosions in bituminous-coal mines in the United States during the calendar years 1906 to 1937, inclusive. The trend was downward from 1907 to 1921, with a marked rise from 1921 to 1924, and a definite, fairly steady, downward trend from 1924 to date; however, the trend has been up in the past 2 years. It is rather significant that every alternate year during the period 1924 to 1936 has shown an increase in the number killed over the preceding year, although the general trend has been down. A possible explanation is that a year with a relatively low explosion-fatality record probably causes a certain amount of relaxation of accident-prevention effort during the following year and, conversely, a high explosion-fatality record acts as a spur toward taking precautionary measures. This later case has been well demonstrated during the past year; following a dust explosion in which 45 men were killed, many operators have rock-dusted their mines for the first time or done re-rock-dusting.

The tabulation on the graph giving average yearly fatalities from bituminous-coal-mine explosions over 5-year periods from 1906-10 to 1931-35 is illuminating, showing, as it does, a heavy and fairly steady decrease in annual fatalities from 438 for the 5-year period 1906-10 to 65 for the 5-year period 1931-35, a decrease of 85.2 percent. The significance of this is seen from the fact that if the rate of explosion fatalities for the 5-year period 1906-10 (438 per year) had continued through 1935, 13,140 lives would have been lost from this cause instead of 7,800 (the approximate number actually lost). If the rate of occurrence of such accidents in the 5-year period 1931-35 (65 per year) had been in effect from 1906 to the end of 1935, the total would have been only 1,950 instead of the approximately 7,800 that actually were killed. Additional significance attaches to the fact that

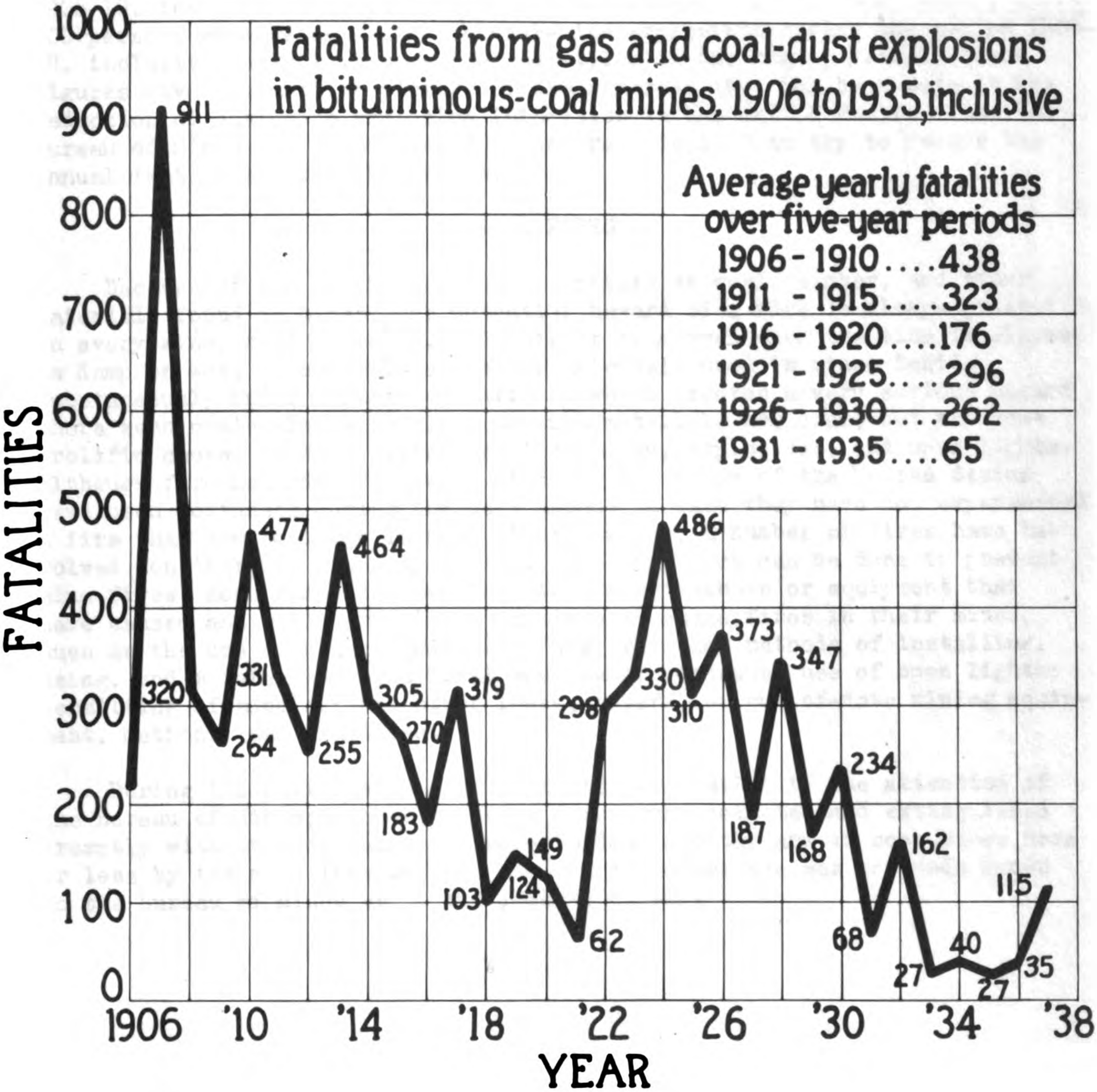
Fatalities from gas and coal-dust explosions in bituminous-coal mines, 1906 to 1935, inclusive
Average yearly fatalities over five-year periods
1906 - 1910....438
1911 - 1915....323
1916 - 1920....176
1921 - 1925....296
1926 - 1930....262
1931 - 1935....65
FATALITIES
1000
900
800
700
600
500
400
300
200
100
0
YEAR
1906
'10
'14
'18
'22
'26
'30
'34
'38
911
320
264
331
477
255
464
305
270
183
319
103
149
124
62
298
330
486
310
373
187
347
168
234
68
162
27
40
27
35
115

Figure 1.

during the past 5 years, 1933-37, inclusive (see the graph), the fatalities from coal-mine explosions in the United States averaged but 49 per year; and if this is compared with the average of 438 annually for the 5-year period, 1906-10, inclusive, the reduction is 88.8 percent; or, in other words, where 100 persons were being killed in coal-mine explosions during the period 1906-10, inclusive, only 11.2 have been so killed in the past 5 years. These figures give a startling picture of the progress that has been made in the reduction of coal-mine explosion fatalities in the United States since the Bureau of Mines was commissioned by Congress in 1910 to try to reduce the annual death toll from that cause.

MINE FIRES

Because of the highly combustible nature of coal, timber, and other materials found in mines, the potential hazard of a fire is always present in every mine, coal or metal, and this is true even when the mine is classed as damp or wet. Some coals and other materials used in mines ignite spontaneously under certain conditions, which creates a very serious hazard where such coals are being mined or such materials are used; but the most prolific causes of mine fires are electricity, explosives, and open lights. Although fire hazards are always present, the mines of the United States have been fortunate during the past decade in that they have not experienced a fire that caused large loss of life; however, a number of fires have involved considerable property damage. Although much can be done to prevent mine fires, some companies continue to employ methods or equipment that have caused and will very likely continue to cause fires in their mines, such as the use of black powder and fuse; slipshod methods of installing, using, and maintaining electrical equipment; continued use of open lights; permitting of smoking; and other loose, unsafe, or out-of-date mining equipment, methods, and practices.

During the past fiscal year 24 fires were called to the attention of the Bureau of Mines; scores of other fires were detected and extinguished promptly without much damage or were handled quietly and in some cases more or less by the mine involved, so that their occurrence was not made known to the Bureau of Mines or to the general public.

TABLE 7. - Comparison of lighting in mines where explosions occurred, fiscal years 1929-38, inclusive

	Open lights		Closed lights		Lighting unknown		Total	
	Number of explosions	Per-cent	Number of explosions	Per-cent	Number of explosions	Per-cent	Number of explosions	Per-cent
1929.............	18	47.4	19	50.0	1	2.6	38	100
1930.............	8	23.5	25	23.5	1	3.0	34	100
1931.............	12	46.2	14	53.8	-	-	26	100
1932.............	15	45.5	14	42.4	4	12.1	33	100
1933.............	7	31.8	14	63.6	1	4.6	22	100
1934.............	9	34.6	14	53.7	3	11.5	26	100
1935.............	6	26.1	17	73.9	-	-	23	100
1936.............	15	60.0	9	36.0	1	4.0	25	100
1937.............	4	20.0	12	60.0	4	20.0	20	100
1938.............	10	34.5	16	55.2	3	10.3	29	100
Total, 10 years	104	37.7	154	55.8	18	6.5	276	100

Table 8 shows that during the past fiscal year 8 fires were reported in Pennsylvania (3 in anthracite mines); 3 in Alabama; 2 each in California, Kentucky, and New Mexico; and 1 each in Colorado, Idaho, Michigan, North Dakota, Ohio, Utah, and West Virginia. Of the 26 fires, 3 were in anthracite mines, 5 were in metal mines, and 1 in a water tunnel. Eight fatalities resulted from the 26 fires; in one instance, two men wearing canister gas masks lost their lives in an attempt to recover the body of a man who had hidden some stolen goods in an abandoned mine; and in another instance, the ventilating furnace in a small wagon mine set fire to the coal and resulted in the death of two men. A carbide lamp set fire to timbers in a metal mine and caused two deaths. Electricity caused 7 of the fires, open lights caused 2, and explosives 1. Of the 14 fires listed under unknown or miscellaneous causes, 9 were of unknown origin, 4 were caused by spontaneous combustion, 1 was thought to have been started by a whiskey still in an abandoned section of a mine, and 1 was started by a ventilating furnace setting fire to the coal rib. The total number of fires (24) reported to the Bureau of Mines during the fiscal year 1938 about equals the average for the preceding 8 years; and the deaths resulting from fires during the past year (8) were slightly less than the average for this period.

SUMMARY

It is interesting to note that of the 25 major coal-mine-fire disasters, with a total of 566 fatalities since 1900, only 4 (with 29 deaths) have occurred since 1921, that no major coal-mine-fire disaster occurred in the United States from 1926 to 1933, inclusive, and that 1 occurred in March 1934, with 5 fatalities, one in May 1935, with 6 fatalities, and 1 in August 1936, with 9 fatalities. The occurrence of 3 major mine-fire disasters during the three years 1934, 1935, and 1936, with a total of 20 deaths, together with the fact that none occurred in the preceding 8 years, would indicate that proper precautions have not been taken in late years in the handling of mine fires, especially in protecting workers who are attempting to fight the fire or those engaged in rescue work from poisonous or asphyxiating gases. This would indicate that our mining people, through long immunity from harm to employees by mine fires, either have become negligent or have forgotten much of the knowledge of the hazard of mine fires and of safe and efficient practices and methods of preventing them and of handling them when they do occur.

The decrease in frequency and severity of explosions in the United States during the past 30 years has been encouraging and indicates that efforts to prevent explosions have been largely successful. The record for the 4-year period, 1934 to 1937, inclusive, was especially good; however, the fiscal year 1938 shows an increase of 73.5 percent in the number of fatalities from explosions, compared with the average of the 4 previous years. This record is anything but encouraging and indicates that lax methods are being employed by some coal-mining companies.

TABLE 8. - Mine fires by States, fiscal year 1938 and 1930-37, inclusive.

State	Lighting used			Fatalities by ignition cause									
				Electricity		Open Lights		Explosives		Unknown or Miscellaneous		Total	
	Open	Closed	Unknown	Deaths	Fires	Deaths	Fires	Deaths	Fires	Deaths	Fires	Deaths	Fires
Alabama...........	-	2	1	-	1	-	-	-	1	-	1	-	3
California.........	1	-	1	-	1	-	-	-	-	-	1	-	2
Colorado..........	1	-	-	-	-	-	1	-	-	-	-	-	1
Idaho.............	-	-	1	-	-	-	-	-	-	-	1	-	1
Kentucky..........	2	-	-	-	1	-	-	-	-	-	1	-	2
Michigan..........	-	-	1	-	1	-	-	-	-	-	-	-	1
New Mexico.........	-	1	1	-	-	-	-	-	-	3	2	3	2
North Dakota.......	1	-	-	-	-	-	-	-	-	-	1	-	1
Ohio..............	1	-	-	-	-	-	-	-	-	2	1	2	1
Pennsylvania.......	-	3	5	1	3	-	-	-	-	-	5	1	8
Utah..............	1	-	-	-	-	2	1	-	-	-	-	2	1
West Virginia......	-	-	1	-	-	-	-	-	-	-	1	-	1
Total, 1938......	7	6	13	1	7	2	2	-	1	5	14	8	1/24
1937..............	7	4	10	9	5	-	-	-	3	2	13	11	2/21
1936..............	16	4	3	1	7	-	2	-	3	3	11	4	3/23
1935..............	7	5	14	11	11	-	1	-	-	-	14	11	4/25
1934..............	10	5	3	-	4	-	-	5	5	1	9	6	18
1933..............	12	6	9	-	7	-	-	-	2	2	18	2	27
1932..............	8	5	8	1	8	-	-	-	3	-	10	1	21
1931..............	12	7	5	-	7	5	3	-	5	18	9	23	24
1930..............	7	8	9	2	9	3	6	-	3	-	6	5	24
Total, 9 years...	86	50	74	25	65	10	14	5	25	26	106	71	208

1/ Includes 6 metal-mine fires.
2/ Includes 5 metal-mine fires.
3/ Includes 12 metal-mine fires and 2 outcrop fires.
4/ Includes 5 metal-mine fires and 4 outcrop fires.

Of the 29 explosions that occurred during the past fiscal year, 27 originated by ignitions of gas and two originated by ignitions of coal dust. In almost all of the gas ignitions it is definitely known or suspected that the ventilation was not adequate or that the regular ventilating circuit had been interrupted. The two dust ignitions were caused by improper use of explosives.

One factor that might be considered as a cause of the increase in explosion disasters (as well as the increase in other causes of accidents) is that during depression periods safety suffers. It is a well known fact that during periods of business depression, the mine foreman and superintendent are required to economize in every way possible and, as a result, safety measures in force that do not appear to pay tangible dividends are discarded. During business depressions false economy may result in neglect of rock-dusting; air courses are not likely to be kept free from falls, and this results in poor ventilation; coal dust is permitted to accumulate along haulage roads or in the gob in rooms; cross-cut stoppings are not installed or are not properly maintained; needed overcasts are not constructed; the fan may be slowed down or stopped on "off" shifts and idle days; supervision is likely to be reduced; and proper inspection for gas may not be made. The lack of any of the foregoing (and additional delinquencies can be cited) might be the contributory cause of an explosion. Disregard of common-sense safety practices and employment of haphazard methods in many coal mines in times of depression are inexcusable and a source of discredit to the industry as a whole.

Some of the salient points brought out in the study of explosions and fires in the United States by the Safety Division of the Bureau of Mines during the fiscal year ended June 30, 1938, are:

1. Twenty-nine explosions were studied, 25 in bituminous mines and 4 in anthracite mines, compared with 20 in 1937 and a yearly average of 27.3 in the previous 9 years.

2. Explosions took 170 lives in the fiscal year 1938, compared with 62 in 1937 and an average of 105 in the previous 9 years. The 4 explosions in anthracite mines resulted in 18 deaths, while the 25 explosions in bituminous mines resulted in 152 deaths.

3. The 8 major explosions caused 146 deaths, while the 21 minor explosions caused 24 deaths. In 10 of the explosions no deaths occurred.

4. Ten of the explosions occurred in open-light mines, compared with 4 in 1937 and a yearly average of 10.5 in the previous 9 years. Sixteen explosions were in closed-light mines, compared with 12 in 1937 and a yearly average of 15.3 in the previous 9 fiscal years. As in previous years, several explosions in closed-light mines were initiated by open flames (matches used by smokers or to light flame safety lamps, carbide lights used to ignite fuse in blasting, etc.).

5. Ten explosions, causing 24 deaths, were of electrical origin, compared with 12 explosions and 53 deaths in the previous fiscal year. Explosions of electrical origin averaged 11, with 61 deaths annually for the previous 9 years.

6. Open lights and smoking caused 11 explosions and 77 deaths in 1938, compared with 5 explosions and 3 deaths in 1937 and an average of 9 explosions and 23 deaths during the previous 9 years. All of these open-light explosions were in bituminous mines; two occurred when fire bosses attempted to relight flame safety lamps with matches. Explosions and deaths caused by open lights showed a definite increase in the past fiscal year, and this should cause those mine operators who still persist in using open lights, to make haste to take advantage of the much safer, much more efficient, much more dependable light afforded by the use of up-to-date electric cap lamps.

7. Six explosions, resulting in 61 deaths, occurred during the fiscal year 1938, compared with 1 explosion and no deaths during the previous fiscal year and to an average of 4 explosions and 16.4 deaths during the previous 9 years. The past year saw a marked increase in the number of explosions and deaths caused by explosives. One of these explosions was caused by an "adobe" shot with permissible explosive; hence, using permissibly explosive in a nonpermissible manner resulted in 45 deaths.

8. Rock dust was used to some extent in at least 10 mines in which explosions occurred during the past year. In a majority of these mines, rock-dusting is credited with being a factor in preventing the spread of the explosion, and it is believed that several hundred fatalities were prevented because of the rock-dusting that had been done.

9. Twenty-seven of the explosions during the past year are thought to have been initiated by gas, and two were purely dust explosions originating as the result of misuse of explosives. In almost all of the gas explosions that occurred during the year it was indicated that the ventilating current had been interrupted and that in some cases inspection for gas had not been adequate. There appears to have been what might be termed an epidemic of locking open important ventilation doors with consequent accumulation of explosive gas and its subsequent ignition.

10. The severity of explosions last year showed a marked increase compared to the average of the preceding 9 years. The average number of deaths per explosion last year was 5.9, compared with an average of 3.8 deaths per explosion for the preceding 9 years.

11. The 170 deaths caused by explosions during the past fiscal year occurred in 12 States; 15 of the coal-producing States had no fatalities from this cause, and several of these States have definitely hazardous conditions as to possible occurrence of explosions.

12. During the fiscal year 1938, 24 mine fires (including 6 metal-mine fires) with 8 deaths were reported, compared with 21 fires and 11 deaths in 1937 and an average of 23 fires and 8 deaths for the preceding 8 years.

13. Seven of the fires were of electrical origin, two were caused by carbide lamps, one was caused by explosives, 3 were of spontaneous origin, and the origin of 11 is unknown.

14. The frequency of mine fires has shown no reduction during the past decade. The potential hazard of fires in any mine is decidedly serious, especially so in coal mines, as they may precipitate explosions.

CONCLUSIONS

This circular was compiled in essentially the same manner as were those of previous years (see Information Circulars 6178, 6419, 6540, 6680, 6751, 6819, 6870, 6927, and 6986) and embodies only facts revealed through studies by field employees of the Safety Division of the Bureau of Mines. Although the Bureau of Mines attempts to obtain information concerning every explosion that occurs in the United States, some of the less destructive may not have been brought to its attention early enough to permit investigation. However, the Bureau rarely fails to acquire fairly complete details of mine explosions in which more than 1 life is lost or in which a considerable amount of property is damaged; therefore, the data in these publications are relatively complete, especially as to explosions causing loss of more than 1 life.

The data on mine fires are by no means as complete as those on explosions, and there is reason to believe that scores of fires in coal and metal mines occur annually without the knowledge of the Bureau of Mines or even the State inspection forces. Mine fires occur almost daily in some coal mines, particularly at shot-firing time or where the coal fires spontaneously; and fires of electrical origin or those caused by open lights are not unusual in metal mines.

A study of data available on mine explosions in the United States during the 9 years preceding the fiscal year 1938 reveals an encouraging reduction in the frequency and severity of these disasters. However, the past year showed a marked increase in both frequency and severity, for which there is good reason to be alarmed. During the past year there was apparently a recession of vigilance over the factors that contribute to explosions; the most important of these factors are the maintenance of adequate uninterrupted ventilation and the restriction or possibly the elimination of gas- or dust-igniting agencies.

In the 20-year period preceding 1929, mine explosions and fires took an average toll of about 285 lives annually in the United States. Since then the average number of fatalities from explosions and fires has been reduced to 118.7. The fiscal year 1934 established an all-time low record - only 34 fatalities resulted from explosions and fires, compared with 178 fatalities from these causes during the fiscal year 1938. An analysis of the record for the fiscal years 1934, 1935, 1936, and 1937 demonstrates that explosions can be largely, if not wholly, prevented and that loss of life from this cause can be greatly reduced. The fact that in the fiscal year 1938 nearly as many men were killed by explosions as were killed during the previous 4-year period is an indictment against the coal-mining industry. There is absolutely no good reason why the trend of explosion accidents should not continue downward, with the ultimate almost complete elimination of this type of accident.